Station Bulletin 171

July, 1920

IMPERIAL BUREAU OF MYCOLOGY
28 JUN 1921

Oregon Agricultural College
Experiment Station

Hood River Branch Station

Spray Gun Versus Rod and Dust in Apple Orchard Pest Control

By

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CORVALLIS, OREGON

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A SHORT ILLUSTRATED STORY OF ORCHARD ECONOMICS

IN FOUR PARTS

Foreword

The complete spraying costs incurred and results obtained in two excellent orchards seventeen years of age have been secured. Both orchards are splendid examples of what a full-bearing orchard should be. The first orchardist is obtaining maximum results in the control of his orchard pests; his neighbor, with natural resources equally good, loses annually an amount sufficiently large to pay nearly twice the total season's spraying charges. This story is illustrated with pennies (represented by 0's), the spraying cost per tree being shown. One grower saves in his spraying cost; the other saves his fruit. Read the story.

Part 1

These 76 pennies illustrate the spraying cost for each tree of the orchard in which pest control was obtained. Less than 5 percent of the fruit was damaged by leaf roller, codling-moth, and scab combined. The trees were thoroughly covered in each application—seven in all.

These 0's represent 76 pennies

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Part 2

These 55 pennies represent the spraying cost for each tree in the orchard where results in pest control were only fair. More than 18 percent of the fruit was damaged by controllable pests. The trees were sprayed seven times—the same number of applications used in the orchard discussed in Part 1. The amounts used on each tree were irregular (as shown in Table XIV of the text) during the season, and it is assumed that the covering was far from complete.

These 0's represent 55 pennies

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Part 3

These 21 pennies show the saving in spray materials and labor accomplished by the second orchardist. He saved 3 cents a tree on each application during the season or 21 cents for the year. This is about $15.00 for each acre of orchard. This appears to be economy, but was it?

These 0's rspresent 21 pennies

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Part 4

These 104 pennies represent the difference between the value of the fruit damaged on each tree in orchard 2 and the value of that damaged on each tree in orchard 1. In other words, the second orchardist saved 21 cents a tree in spraying charges but lost 104 cents more in fruit than the first orchardist. This additional spraying cost in orchard 1 netted 495 percent on the investment. Which economy are you practicing? Study the cost tables and the tree requirements shown and discussed in the latter portion of this bulletin. It may help toward the perfection of your pest control.

These 0's represent 104 pennies

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Spray Gun Versus Rod and Dust in Apple Orchard Pest Control

INTRODUCTION

During the past fifty years in many parts of the United States much has been written on the control of the codling-moth and its life-history. It would seem that this exhaustive treatment of the subject would eliminate the necessity of continuing further investigational work in this field. Such is not the case, however. Present-day investigators are finding many important facts which were not recognized by earlier workers, especially with reference to temperature and locality variations, which from one season to another materially alter control recommendations. More recent investigations, to a greater or less extent, explode some of the fundamental ideas of control advocated by the earlier entomologists—particularly of calyx-worm control.

The evolution which has taken place in spraying equipment—from the bucket and barrel pumps to our modern sprayers equipped with power similar to that of the automobile—has made it necessary that the entomologist and pathologist keep up with mechanical improvement. In order to do this, it has been essential to continue experimental work in the control of the codling-moth and other orchard troubles in order that the most efficient means might be determined.

The data presented in this bulletin cover a four-year period, 1916, 1917, 1918, and 1919. The work has been carried on as a cooperative experiment in connection with work for control of the apple scab. The discussion of scab control will not be taken up in this bulletin; cost figures, however, will be included, since the respective means of control for these two apple troubles go hand in hand in most sections. The most promising of present-day equipment has been tested out, one against the other, in order to furnish the orchardist with information which might serve as a guide in the economics of spraying and codling-moth control.

The more important points discussed are the dusting method vs. liquid method, the spray gun vs. the spray rod, and high-powered equipment vs. medium- or low-powered equipment. In this discussion the more important features will be the relative degree of codling-moth control obtained and the economy, in dollars and cents, as well as labor, to the orchardist.

At the time the experimental work was started (1916) the spray gun and the high-powered sprayer, now rapidly coming into use, were entirely unknown in the West. Work with the spray gun and high-powered outfits did not begin until 1917.

Following the publication of the work of Reddick and Crosby* on control of various apple insects with dust materials, there was a very great demand on the part of Western growers for information relative to the merits of the system, their chief interest in the matter being the need of a more rapid, and if possible, a more economical method of applying sprays. Another important point was to determine if it was possible to use sulfur dust in the so-called "30-day spray" as a means of late scab control. The use of lime-sulfur in this application was not safe under all conditions, as quite often serious burning of the fruit resulted, if hot weather followed the application within two or three weeks.

The data herein presented have been obtained through cooperation with local orchardists in the Hood River Valley. Representative orchards were chosen in different parts of the Valley so that the figures given are obtained from typical Western orchards. The experimental blocks, for the most part, are of sufficient size to permit the drawing of definite conclusions. In the control work with liquid applications a 200-gallon tank was the usual unit employed. For the dusting experiments one- and three-acre units were used. In most of the orchards the trees were twelve to fourteen years old when the work was started. In several orchards the experimental work has been continued since its inception four years ago. At different times, other orchards were chosen where information was desired on some particular point. Cost figures are based on statistics obtained in orchards of ten to forty acres in size and from orchardists who have been highly successful in their pest control.

In these various tests numerous types of sprayers and accessories have been used, including the Kansas City and Niagara power dusting machines; the Hardie, Bean, and Friend power outfits of different horse-powers; as well as some "home assembled" power machines. A large variety of standard accessories on the spray rods, and several makes of spray guns have been used. Trade names are avoided in the text. In the latter part of this discussion, growers can draw from inference the general type of equipment that is best suited to their needs.

The data that have been gathered during the four years of work are necessarily bulky, with many duplications accruing from year to year as the work progressed. This mass of information would be of interest to few readers, and for most growers a summary of the important points would seem more desirable. For this reason the subject-matter is condensed as much as possible.

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*Bulletins 354 and 369. Agr. Exp. Sta. Cornell Univ.

CODLING-MOTH CONTROL WITH DUST, SPRAY ROD, AND SPRAY GUN

1916 TESTS

The dusting tests for this year were checked against blocks sprayed with rods only. During this season, the dust work was carried on in a more or less preliminary way in order to learn whether such a method could be conducted on a large scale with any degree of safety to a cooperating orchardist. It was also necessary to learn the technique of dusting in order to be prepared to conduct an experiment on a sufficiently large scale, including costs and control, in a satisfactory manner. Twenty large trees were used in the dust experiment, R-1 (Table I). The results from this experiment were checked against R-2 (sprayed with rods throughout the season) and unsprayed check trees. Six applications were given during the season as shown in Table I.

TABLE I. SPRAYING SCHEDULE ORCHARD 1, 1916. DUSTING VS. SPRAYING

Exp. No.	Delayed dormant	Pink spray	Calyx spray	15-day spray	30-day spray	3d cod-ling-moth spray
R. 1	Corona dusting mix 85-15 (sulfur-lead)	Corona dust	Corona dust	Corona dust	Corona dust	Corona dust
R. 2	Lime-sulfur 1-18 (rods)	Lime-sulfur 1-25	Lime-sulfur 1-35 A. of lead 5-100	Lime-sulfur 1-35	Lime-sulfur 1-50 A. of lead 5-100	A. of lead 5-100
R. 3	Un-sprayed check					
Date of application	April 10, 1916	April 27	May 10	May 23	June 19	August 22

Paste lead used.

The results obtained from this set of experiments were not satisfactory from the standpoint of information relative to codling-moth control. The summer of 1916 was very cold, following a wet, cold spring. At Hood River but one generation of codling-moth occurred, with the result that no worminess existed on the unsprayed check trees at harvest time. The first brood worms were not checked up. Very good control of scab was obtained, however, and it was found that sulfur dust would cause an injury similar to that of lime-sulfur when applied during hot weather. This injury was not very serious on account of the prevailing cool weather. A very serious injury occurred in the calyx end of many apples, where a black, apparently burned, ring occurred. It is believed that this injury was occasioned by the dust material in the calyx application which was applied while a good many petals were still present. Much wet weather and some frost followed, thus complicating the matter. The sprayed trees adjoining, which received an application two days later, did not show this injury to any great extent. The results obtained are shown in Table II.

TABLE II. RESULTS IN ORCHARD 1, 1916. DUSTING VS. SPRAYING

Experiment No.	Apples counted	Percent scab	Percent burn	Percent moth injury
Dust block R-1	1027	% 3.70	% 5.15	% 1.9
Sprayed block R-2	3014	2.65	3.68	0.0
Unsprayed check	704	60.22	.0	1.3

The year's test brought out the following points: (1) Scab could be controlled with properly applied dust. (2) Codling-moths of the first brood were checked, though no figures were obtained relative to the degree of control. (3) Dust sulfur would burn during hot weather. (4) No foliage injury was observed in the dust block, while considerable

Fig. 1. Delayed dormant stage. Left, fruit buds. Right, leaf buds. Plant development at time of first application of sulfur dust and lime-sulfur.

burning of the tender foliage occurred in the delayed dormant and pink applications made with lime-sulfur. (5) Dust could not be applied satisfactorily during windy weather or at times when even a breeze was blowing. With these facts in mind, rather extensive experimental work was outlined for the year 1917 in order that figures on cost and control might be obtained.

1917 TESTS

The results of the 1916 tests with dust were sufficiently promising to warrant further work in 1917. The work was primarily a test of the dusting method as compared with the liquid, where 12-foot rods were used to apply the spray. Tests with the spray guns were not undertaken before the calyx application during this season. Dusting experiments were conducted in three orchards, consisting of two three-acre blocks and one one-acre block. These tests were checked against blocks of similar size in the same orchards, to which regular applications of liquid sprays

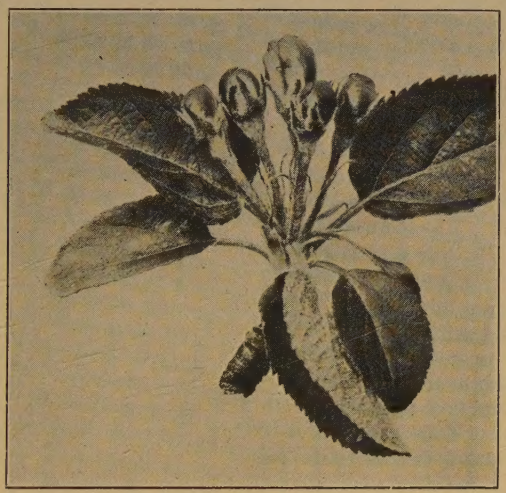

Fig. 2. Pink stage. The fruit buds should be allowed to separate in the clusters before the spray is applied.

were applied. The trees in these blocks were all in full bearing, about thirteen years of age. Orchard 1 included the same trees of the Newtown variety that were dusted in 1916. Orchard 2 included a three-acre block divided equally into Newtown, Spitzenburg, Jonathan, and Arkansas Black varieties. This orchard had been quite wormy for a number of years and was chosen largely for this reason. Orchard 3 consisted of a three-acre block of Newtowns and Spitzenburgs. All of the orchards chosen were typically representative in all respects. The schedule in Table III shows the method of application, amounts used, and dates of spraying in the various orchards.

METHODS OF APPLICATION

The dust materials were applied in the same manner in the different orchards, standard power dusters being used. It was first attempted to dust the trees from one side only, but this was found impracticable owing to the fact that it was impossible to insure complete covering of all parts of the tree. This plan was abandoned and the trees in all experiments were dusted from both sides throughout the season. The team was driven slowly down each row, pausing for a moment at each tree to apply the dust. For the smaller trees this pause was not necessary. For the most part the dusting was done very early in the morning, owing to the fact that wind began blowing after 8 o'clock. Windy weather was avoided throughout the tests in all of the experimental work, complete covering being impossible when even light breeze prevailed.

The stages for the different applications are those that have been found to be most effective in earlier work,* and applications were made when foliage development was practically ideal in all of the tests. See Figs. 1, 2, 3. In actual application, as the trees were approached, a cloud of dust was blown over the top of the tree (Fig. 4), and the covering was completed with the zig-zag motion backwards from the end of the original arc. In this way, an effective covering was given very rapidly and with the exertion of comparatively little energy.

In the liquid blocks, the equipment used was alike for orchards 1 and 3, a standard 3½-horse-power sprayer equipped with 12-foot rods being used. In orchard 2 a home-assembled machine was employed, which was equipped with 12-foot rods. This machine gave a good deal of trouble from low pressure, with the consequence that at times poor work resulted. This probably accounts for the fact that the orchard has been quite wormy in years past.

MATERIALS USED

The materials used in the different orchards during the tests of 1917 were of much the same character in chemical composition. Physical

*Report of Hood River Branch Experiment Station, 1914-1915. Oregon Agricultural College Experiment Station Bulletin 143. 1917.

TABLE III. SPRAYING SCHEDULE 1917, ORCHARDS 1, 2, AND 3, DUSTING VS. SPRAYING

Orchard	Exp. No.	Delayed dormant spray	Pink spray	Calyx spray	15-day spray	30-day spray	3d codling-moth spray
1	R-4 dust	Corona dust 85-15*	Corona dust 85-15	Corona dust 85-15	Omitted	40-50-10†	85-15§
	R-5 spray	Lime sulfur 1-20	Lime sulfur 1-25	Lime sulfur 1-35 Lead 4-100	Omitted	A. of lead 4-100	A. of lead 4-100
2**	R-6 check	Not sprayed					
	J-1 dust	Sulfur dust	Sulfur dust	40-50-10	Omitted	85-15	85-15
	J-2 spray	Lime sulfur 1-20	Lime sulfur 1-25	Lime sulfur 1-40 A. of lead 4-100	Omitted	A. of lead 4-100	A. of lead 2-100
3	J-3 check	Not sprayed					
	F-1 dust	Sulfur dust	Sulfur dust	40-50-10		40-50-10	85-15
	F-2 spray	Lime sulfur 1-20	Lime sulfur 1-28	Lime sulfur 1-40 A. of lead 4-100	Omitted	A. of lead 5-100	A. of lead 5-100
	F-3 check	Not sprayed					
Dates of application	Orchard 1	May 5, 1917	May 16, 1917	June 4, 1917	Omitted	July 4, 1917	Aug. 16 1917
	Orchard 2	Apr. 30, 1917	May 11, 1917	June 2, 1917	Omitted	July 1, 1917	Aug. 11, 1917
	Orchard 3	May 4, 1917	May 14, 1917	June 5, 1917	Omitted	June 30, 1917	Aug. 10, 1917

* Corona dust = 85 sulfur, 15 lead.
†40-50-10 = 40% filler, 50% sulfur, 10% ars. lead.
§85-15 = 85% filler, 15% ars. lead.
**Some blocks in orchard 2 dusted and sprayed extra in Sept.

properties were somewhat different, dependent upon the source of materials. The Corona Dusting Mixture, composed of 85 percent sulfur and 15 percent arsenate of lead, a very finely divided powder, fluffy and light, was quite easily and effectively applied. In general, this material had the best quality, physically, of all the materials used. The diluted dust, of formula 40-50-10, (filler, sulfur, and lead), known as the Niagara Dusting Mixture, was supplied in bags and had a tendency to become lumpy. Some loss resulted from these lumps falling to the ground. The 85-15 (85 percent filler and 15 percent arsenate of lead), obtained from the same source, was used in the later applications in order to avoid sulfur injury of the fruit. To accomplish the best coating and the use of a minimum amount of materials, it was found that there was a decided need for a very fine, dry material, which, when put up in containers, would not become balled or packed. In the liquid blocks, standard mixtures of lime-sulfur and lead arsenate were used in all three orchards. (See Table III.)

Fig. 3. The calyx stage. Apply the spray as soon as the petals have fallen.

RESULTS IN WORM CONTROL, 1917

From the standpoint of worm control, orchard 1 gave little or no results. This orchard was practically free from codling-moth in 1916 and failed to develop any great amount of worminess. The unsprayed checks showed an infestation of but 2.71 percent.

On account of the large number of worms which developed upon the unsprayed check trees of orchard 2, the value from the use of dust and liquid sprays in worm control is very decidedly pointed out. Four varieties of apples were used in the tests. These were Newtown, Spitzenburg, Jonathan, and Arkansas Black. A summary of results obtained for the Arkansas Black variety is given in Table V. More complete notes were kept of this variety throughout the season, and, for the sake of brevity, the results obtained with the other varieties will not be

Fig. 4. Applying dust sulfur and arsenate of lead with a power duster. To give an effective coating dust must be applied under absolutely quiet atmospheric conditions. Prevalence of winds and the limited use of dusting method in combating different orchard pests do not make its use advisable in the Northwest.

discussed critically. For the most part, the control obtained was quite constant. There were exceptions, however, in some of the figures obtained.

Generally speaking, the worm injury which occurred throughout the dust block was more prominent than that which occurred on the sprayed trees. A greater portion of the injury appears in the form of "stings," which prevailed quite generally through the blocks. The average percentage of injury from "stings" was about 20 percent, a very high percentage, ranging from 5 to 35 percent in the different varieties. This condition has not been consistent in the different orchards during the different seasons, and is believed to be the result of some local influence.

A block of trees adjoining the dust block was sprayed for fruit, only, during 1917. This poorly sprayed block became very wormy and developed a high percentage of stings. There is a packing-house near this test block through which many wormy apples have passed. Progressing away from these conditions, a decrease in the injury occurs. This is especially true with reference to the percentage of stings.

In experiment J-2-a (sprayed) which adjoined this poorly sprayed block, the fruit developed an injury from stings of 22.67 percent, with a worminess of 10.06 percent at harvest time. Four rows away from this block (and further away from badly infested trees) the codling-moth infestation was 9.19 percent and the damage on account of stings amounted to 14.13 percent. All of the apples from several trees in these experiments were recorded throughout the season, and the total worminess including first and second brood worms is shown in Table V. Unfortunately a record was not kept of all the fruits from trees in the blocks which received an extra application of spray in September, J-7 (sprayed) and J-8 (dusted). The record of these blocks, which were still farther away from the wormy condition described above, shows much better control and indicates the very great necessity of applying a late spray during some seasons. In these experiments, the sprayed trees were much freer from codling-moth damage than the dusted blocks, the injury being 1.43 percent wormy as compared to 5.37 percent where the dust was used. Where sprayed, 10.11 percent of the fruit developed stings, while 16.13 percent was so affected in the dust block.

Considering the fact that great care was used in timing and applying the dust, the results following its use in this orchard cannot be considered entirely satisfactory, and leave one rather in doubt as to the advisability of using dust in a badly infested orchard. The irregular conditions surrounding the experimental blocks, together with the fact that good codling-moth control has been obtained in the majority of tests, make it inadvisable to condemn the dust on the basis of these results. Actual worminess was kept well in hand considering the number of moths present. A summary of the results obtained with the different varieties in this orchard gives the following figures: Unsprayed Newtowns developed 55.04 percent worminess; in the dusted block a 5.89 percent infestation occurred; while the sprayed trees developed 2.41 percent. Unsprayed Spitzenburgs developed 54.49 percent infestation; dusted 8.99 percent; sprayed 1.62 percent; Jonathan check trees developed 80.53 percent worminess; dusted 6.37 percent, and sprayed 1.61 percent. These blocks were adjoining, but so located that little or no dust drifted into the sprayed plots.

Fig. 5. The range of effective spraying is much greater with high-powered sprayers than with smaller machines. This is a 10 h. p. rig. Note the fine, drifting quality of the spray in the top of this high oak. To be entirely effective the spray gun must be backed up with liberal power.

ANALYSIS OF CONTROL OBTAINED DURING 1917

In order to obtain definite information relative to the way in which dust accomplished control—particularly calyx-worm control—and the degree in which first and second brood worms are destroyed by the poison, a careful analysis of fruits from the Arkansas Black blocks was made. All of the fruits borne on several trees which were dusted, or sprayed, and on unsprayed checks, were recorded. This included all fruits thinned and those that dropped on account of first brood infestation from the codling-moth. All wormy fruits were opened and whether the worm had entered through the calyx or at some other point was determined. For convenience, entrants other than calyx worms have been called "side" worms in text and tables. Some of the results obtained are irregular but, in the main, point out some interesting facts. The percentage of worminess is much higher than should have been the case. The value of an extra application of dust early in September is shown in the results.

TABLE IV. FIRST BROOD INFESTATION CODLING-MOTH, ORCHARD 2, 1917. DUSTING VS. SPRAYING

Experiment number	Variety and treatment	Total* apples	Apples wormy	Percent wormy	Total stings	Percent stings	Calyx worms	Percent calyx worms	Side worms	Percent side worms	Ratio of calyx to side worms in percent
				%		%		%		%	%
J-1	Arkansas Black dusted	3340	126	3.77	4	.12	45	1.34	81	2.4	35.71 to 64.29
J-2	Arkansas Black sprayed	1451	62	4.27	8	.55	40	2.75	22	1.51	64.55 to 35.45
J-3	Arkansas Black untreated	1440	271	18.81	2	.13	198	13.74	73	5.07	73.04 to 26.96

*Figures include all apples borne on trees during season.

First Generation Worms. The wormy fruit was checked as it dropped from the trees during the summer. Side and calyx worms were recorded as well as those fruits bearing stings. All of the apples infested with first brood worms had dropped from the trees before second generation worms had developed sufficiently to cause a drop. The percentages are based on all fruits borne on the trees, including the apples that dropped during the summer. The percentage of injury thus resulting from first brood worms is shown in Table IV. It was found that 18.81 percent of the apples on the unsprayed check trees became wormy. In the dusted block 3.77 percent of the apples were found to be wormy and in the sprayed block 4.27 percent. It is interesting to note that 73.04 percent of the worms on the unsprayed trees entered through the calyx end of the apple; 35.71 percent where dusted; and 64.55 percent where sprayed.* First-brood losses are not often recognized by the orchardist owing to the fact that these fruits have fallen and rotted long before harvest time.

* This percentage is possibly in error. It was the only exception in effective calyx-worm control encountered during the years of observation.

Where worms are numerous this loss can mean a very important percentage of the crop. The reduction of this loss means not only a saving of fruit but a very great help in combating the second-brood worms.

Calyx-worm Control with Dust. To the investigator working on the control of codling-moth, nothing could be more significant than the figures shown in the last column in Table V. The proper method for placing poison in calyx cups in order to control calyx worms has been much discussed.

At the present time, a great deal of difference in opinion exists, numerous entomologists contending that the only way in which this may be accomplished is through the use of a driving spray directed towards the calyxes largely from above. Information relative to this point becomes especially important on account of the appearance of the spray gun. It is obvious that a majority of the calyx cups cannot be hit directly by spray thrown from a gun. Reddick and Crosby demonstrated that codling-moth control could be obtained with dust. They do not discuss how this control was obtained, however, or give the relative percentages of calyx and side worms in their results. In all tests that have been made at Hood River, covering a three-year period, dust, where properly applied, has consistently controlled calyx worms. The results of numerous experiments could be presented here, demonstrating this point.

TABLE V. FIRST AND SECOND BROOD INFESTATION CODLING-MOTH, ORCHARD 2, 1917. DUSTING VS. SPRAYING

(Injury presented in Table IV included)

Experiment number	Variety and treatment	Total apples	Apples wormy	Percent wormy	Total stings	Percent stings	Calyx worms	Percent calyx worms	Side worms	Percent side worms	Ratio of calyx to side worms in percent
				%		%		%			% to %
J-1-a	Arkansas Black dusted	3340	433	12.96	476	14.25	123	3.68	310	9.28	28.4 to 71.6
J-2-a	Arkansas Black sprayed	1451	208	14.33	337	23.22	55	3.79	153	10.54	26.45 to 73.55
J-3-a	Arkansas Black untreated	1440	938	65.13	90	6.25	641	44.51	297	20.62	68.32 to 31.68
J-7	Arkansas Black* sprayed	1048	15	1.43	106	10.11	3	.28	12	1.14	20.0 to 80.0
J-8	Arkansas Black* dusted	1060	57	5.37	171	16.13	4	.37	53	5.0	7.1 to 92.9

*Extra spray applied; first brood worms not included in record.

In referring to Table IV, it will be noted that 73.04 percent of the first-brood worms entered the apples through the calyx ends on unsprayed Arkansas Blacks, and 26.96 percent entered the fruit through the sides (Exp. J-3). In the dust block (Exp. J-1) 35.71 percent entered the calyx and 64.29 percent entered the side. On the sprayed block 64.55 percent entered the calyx and 35.45 percent entered the side (Exp. J-2). The high ratio of calyx worms to side worms occurring in this experiment has been the only exception noted with reference to calyx-

worm control in all of the tests made. This may possibly be due to to an error in recording the condition of the fruit at the time. The influence of dust in calyx-worm control of the first brood is demonstrated. Table V gives the final summary of results obtained in these blocks. This includes both first and second generation worms. The unsprayed trees developed 68.32 percent calyx worms and 31.68 percent side entrants (Exp. J-3-a); the dusted block, 28.4 percent calyx worms and 71.6 percent side worms (Exp. J-1-a). In the sprayed block at harvest time a ratio of 26.45 percent to 73.55 percent calyx and side worms, respectively, existed (Exp. J-2-a). The presence of the insecticide in the form of either dust or spray practically reversed the ratio which existed on the unsprayed trees. In the blocks where an extra application was used, control was much better. The ratio in the control of calyx worms is even greater. This influence in calyx-worm control through the application of dust is again shown in Table VII, which shows comparative results obtained with dust and spray gun. (1918 tests.)

The results that were obtained with dust in experimental work above described do not demonstrate the control that can be expected in the average orchard where chances of infestation are not aggravated by outside influences. In orchard 3, a similar three-acre block was dusted throughout the season, following a schedule of application shown in Table III. The work was done in the same way as described for orchard 2. The Newtown variety was used in these tests and the dusting method was checked against spray applied with rods and against unsprayed trees. The unsprayed trees developed 18.07 percent wormy apples and 11.05 percent stings. Only 1.74 percent infestation occurred on the dusted trees while 1.83 percent injury resulted on adjoining sprayed trees. On dusted and sprayed trees respectively, 10 percent and 7.1 percent sting injury occurred. Worminess in this degree is not severe and the results obtained with either system can be considered effective.

The presence of stings on unsprayed trees has been observed in variable degrees during many seasons. The percentage of this type of injury in this particular case (11.05 percent) is higher than usual. According to many investigators, stings only occur on sprayed trees, the injury being done by the young worms as they take their fatal dosage of poison. Stings do occur, however, on trees that have received no poison.

In this particular orchard calyx-worm control was again obtained by the use of dust. On unsprayed trees, 38.46 percent of the worms entered through the calyx opening. In the dusted blocks, 100 percent calyx-worm control was obtained and but 14.81 percent of the worms entered the calyx end of the apples on the sprayed trees.

Calyx Entrants versus Side Entrants. It has been observed that the percentage of calyx entrants on unsprayed trees is a very variable factor from one season to another, as well as in different varieties of apples, during the same season. One would be led to believe, in reviewing the literature upon the subject, that a majority of the worms enter through the calyx openings if spray is not applied properly to prevent them from so doing. This is not the case in Hood River at least. During most seasons and with most varieties a much greater proportion of the worms enter the sides of the fruit than through the calyx ends. In

1917, the Arkansas Black variety, figures for which have just been given, was the exception. During this year, unsprayed Spitzenburgs developed 33.04 percent of calyx worms and 66.96 percent of side worms. Unsprayed Newtowns developed 38.47 percent calyx and 61.53 percent side worms. In 1918 and 1919 Newtowns developed even smaller percentages of calyx worms, 26.7 percent and 20 percent respectively. In 1919, unsprayed Spitzenburgs developed 54.83 percent of calyx worms.

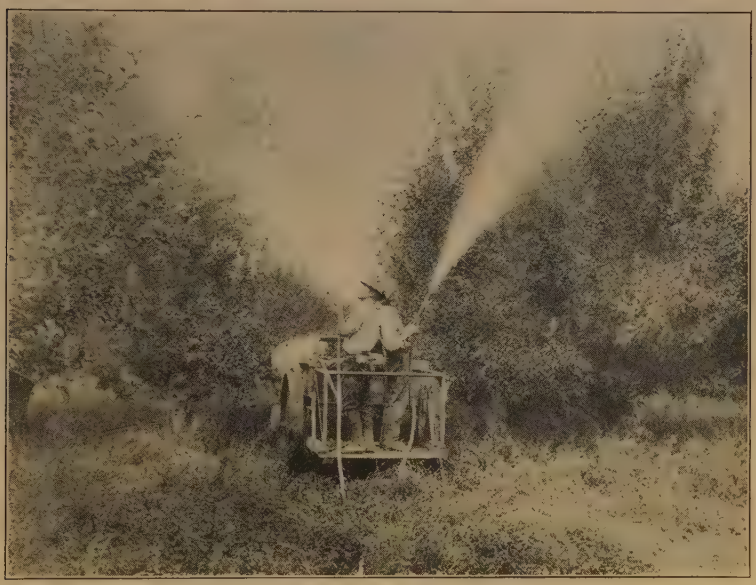

Fig. 6. In some orchards growers who possess high-powered sprayers are spraying from a platform built on the back of the machine. Where this is practiced the machine passes up and down each row of trees one side of which is sprayed in passing. Whether this is an entirely satisfactory practice has not been determined but it at least makes the work much less laborious.

These observations have led the writer to believe that the value of calyx application has been greatly over-emphasized; a condition which has had a tendency to detract, in the mind of the orchardist at least, from the importance of cover sprays in the Northwest. The result has been losses in many sections from worm injury which could have been greatly reduced by the use of well-timed cover sprays applied during middle and late summer.

1918 AND 1919 TESTS

Dusting was continued during both of these years largely to obtain further data relative to scab control. Favorable weather conditions, together with a very complete spraying campaign conducted throughout the Valley have greatly reduced the virulence of this disease. This sanitary measure has been so thoroughly executed that unsprayed check trees have failed to contract the disease in sufficient amounts during recent years to permit the drawing of any conclusions. A summary of

TABLE VI. SPRAYING SCHEDULE ORCHARD 1, 1918 AND 1919 DUSTING VS. SPRAYING

Exp. No.	Delayed dormant	Pink spray	Calyx spray	15-day spray	30-day spray	3d codling-moth spray	Sept. spray
1918							
R-7 dust	Corona dust 85-15 (sul-lead)	Corona dust 85-15 (sul-lead)	85-15 sulfur-lead	Omitted	85-15 (filler and lead)	85-15 (filler and lead)	85-15 (filler and lead)
R-8 spray gun	Lime sulfur 1-25	Lime sulfur 1-35	L. sulfur 1-45 A. of lead 4-100	Omitted	A. of lead 4-100	A. of lead 4-100	
R-9 check	Untreated						
Date of application	Apr. 20, 1918	Apr. 30, 1918	May 16. 1918	Omitted	June 8, 1918	July 29, 1918	Aug. 28, 1918
1919							
R-10-a dust	Miscible oil 6-100	Corona dust 85-15 (sul-lead)	Corona dust 85-15 (sul-lead)	90-10 (filler and lead)	90-10 (filler and lead)	90-10 (filler and lead)	Omitted
R-10 dust	Miscible oil 6-100	Corona dust 85-15 (sul.-lead)	Corona dust 85-15 (sul-lead)	85-15 (filler and lead)	85-15 (filler and lead)	85-15 (filler and lead)	Omitted
R-11 spray gun	Miscible oil 6-100	Lime sulfur 1-25	L. sulfur 1-35 A. of lead 2-100	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100	Omitted
R-12 check	Miscible oil 6-100	Untreated					
Date of application	Apr. 3, 1919	Apr. 30, 1919	May 13, 1919	June 6, 1919	June 21, 1919	Aug. 8, 1919	Omitted

Note:—Paste lead used at rate of 4-100; powder, 2-100.

the results that have been obtained is interesting in that they further demonstrate the way in which the codling-moth is controlled. Table VI gives the method of application for both years and Table VII gives the results obtained. These conclusions are consistent with the earlier work which has been discussed.

The spraying schedule (Table VI) was not entirely regular during these two years, alterations being made to meet conditions of weather, plant development, and insect and disease activities. These factors involved in following out a spraying schedule during different seasons will be discussed later.

THE DUSTING METHOD IN PRACTICE

Provided all conditions are right, there is probably no easier and more effective way of coating a tree with an insecticide, such as powdered sulfur and arsenate of lead, than by the use of a power duster. The factor called "conditions," however, decidedly limits the general utility of the plan. Thrown from the duster, air is the carrier used in placing the fine particles on all portions of the tree. A wonderful coating can be given a tree even to its uppermost branches. The upper and under surfaces of the leaves as well as the fruit can be thoroughly coated. The fine hairs on these surfaces hold the minute particles and it requires much weathering to dislodge them. This air conveyor being in motion, however, a slight breeze upsets the plan of procedure; a breeze makes it almost impossible to hit the top and even if this is accomplished, the particles are moved past the surfaces so rapidly that only a very small percentage sticks. The remainder passes on and is for the most part wasted. When the wind is blowing, nothing can be done. When the air is quiet, the particles hover for a long time on a tree (Fig. 4) and gradually settle. Air currents destroy the plan of the system and applications made under such conditions can only result in failure.

In carrying on the experimental work, it was found necessary to dust very early in the morning and thus avoid air movements which usually became sufficiently strong by 8 o'clock to prevent thorough work. During the spring months, it is not uncommon for wind to blow in varying degrees continuously for days at a time. Many times the experimental work was delayed for more favorable weather conditions. We are all familiar with the fact that the application of spray cannot be delayed to any great extent and at the same time accomplish successful results. Several growers have used the dusting method; for the most part, their work has been done regardless of air movement. In 1918, the condition of the fruit in one of these orchards was checked and 33 percent of the fruit was found damaged by the codling-moth.

The dusting method is also decidedly limited in its general utility. Of our various orchard troubles, it will only satisfactorily control scab and codling-moth. Mildew, anthracnose, leaf-roller, and the various scale insects are unaffected by dust applications at present known and must be handled with liquid spray. The use of the duster would then mean duplication of equipment and an overhead charge that the average-sized orchard cannot stand. For these reasons, the duster has little place in Western orchards at the present time.

THE SPRAY GUN VS. THE SPRAY ROD

The wide acceptance of the gun on the part of many orchardists throughout the country, with little or no experimental evidence as to its effectiveness, is a decided exception to the caution with which farmers usually look upon "new-fangled" appliances. The war and the accompanying labor shortage forced the spray gun into use. In many instances, it was either a case of using the spray gun or doing little or no spraying during this time.

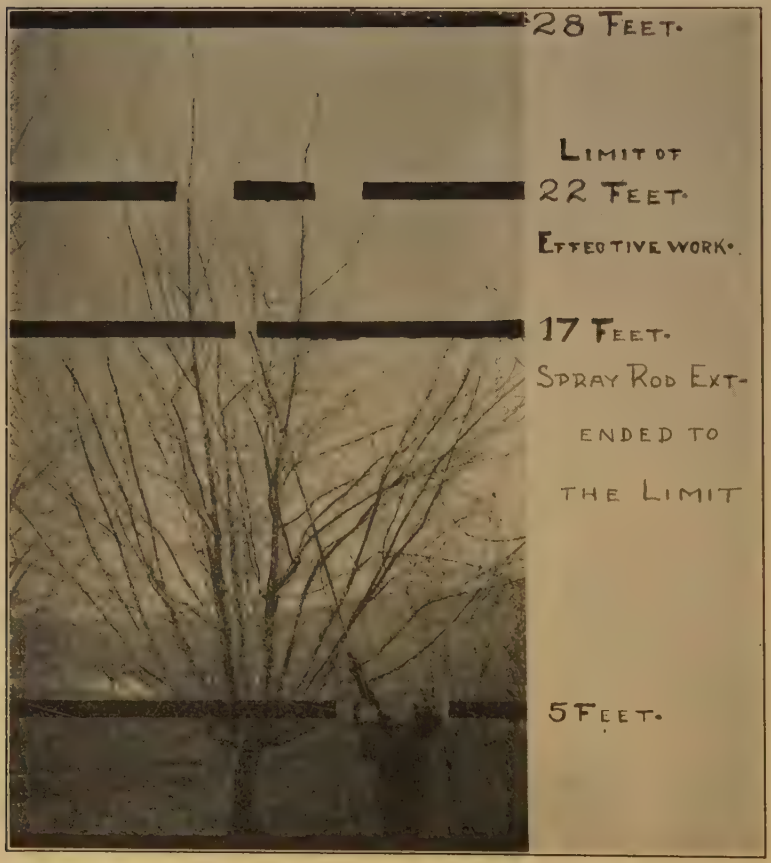

Fig. 7. This shows the position of the nozzles relative to the height of the tree when the rod is held at arm's length. Note that there is much surface above this point. Worminess rapidly increases above this point.

The interesting results obtained with dust in calyx-worm control led the writer to believe that sprays, properly applied with a gun, would accomplish the same results. The first test with a gun began with the calyx spray in 1917 (Exp. R-5 Table III). The results did not give much information owing to the fact that the check trees developed but

6.27 percent of wormy apples. Only .37 percent worminess developed on the sprayed trees. In view of the fact that the entire orchard had been sprayed with guns, the failure on the part of the worms to do much damage was decidedly encouraging. This orchard, referred to as No. 1 throughout the text, has been sprayed continually with guns since that time. A large 10-horse-power machine was used which delivers a very finely divided spray, possessing great carrying properties (Figs. 5, 6, 9, 11). The original supposition that finely divided liquid would act in the same way as dust, has been borne out in the results obtained in this orchard during both 1918 and 1919. In checking the apples during both of these seasons, not a single calyx worm was found. (Note the results of this work in Table VII, Exps. R-8 and R-11). The check trees developed, respectively, 17.64 percent and 12 percent worminess during these seasons.

TABLE VII. RESULTS OBTAINED IN CODLING-MOTH CONTROL, ORCHARD 1, 1918 AND 1919. DUSTING VS. SPRAYING

Experiment number	Total apples	Apples wormy	Percent wormy	Total stings	Percent stings	Calyx worms	Percent calyx worms	Side worms	Percent side worms	Ratio of calyx to side worms in percent
						1918				
			%		%		%		%	% to %
R-7 dust	1336	36	2.68	30	2.24	2	.14	34	2.54	5.3 to 94.7
R-8 spray gun	1132	5	.44	8	.7	0	.0	5	.44	0.00 to 100
R-9 check	1168	206	17.64	40	3.42	55	4.7	151	12.9	26.71 to 73.29
						1919				
R-10-a dust	1019	54	5.28	26	2.55	5	.49	49	4.8	9.26 to 90.74
R-10 dust	1003	31	3.09	12	1.19	1	.09	30	2.99	3.23 to 96.77
R-11 spray gun	1042	19	1.82	26	2.49	0	.0	19	1.82	0.00 to 100
R-12 check	1075	129	12.0	21	1.86	25	2.32	104	9.67	19.38 to 80.62

In order to get a more complete line on the calyx-worm control with a spray gun, an orchard was chosen in 1919 which was known to have been very wormy during 1917 and 1918. The test thus far had been carried on in an orchard where no serious amount of damage had occurred on the unsprayed check trees. Since it was impracticable to include a dust experiment in this orchard, twelve-foot rods equipped with angle nozzles were tested against the spray guns.

The varieties used in the test were Jonathan, Newtown, and Spitzenburg. The trees were of good size, sixteen years of age. Three blocks were chosen through the center of the orchard cutting rows of each of these varieties. One block was sprayed with guns throughout the season, another sprayed with twelve-foot rods throughout the season, and still another was sprayed in the calyx application with rods; while in the other applications guns were used (see Table VIII). The spray was applied by the owner and his hired man under the supervision of the writer, who in each application followed behind the men while the trees were being sprayed. Two guns were used on a new 3½-horse-power outfit of well-known make. The guns were exchanged for the rods in the different applications. The spraying schedule and dates of application are shown in Table VIII. The results of these tests for the Spitzenburg

TABLE VIII. SPRAYING SCHEDULE, CODLING-MOTH, ORCHARD 4, 1919 SPRAY RODS VS. SPRAY GUNS

Exp. No.	How applied	Delayed dormant	Pink spray	Calyx spray	15-day spray	30-day spray	3d codling-moth	Sept. codling-moth spray
A-1	12 ft. rods and angled nozzles	Lime sulfur 1-25	Lime sulfur 1-30	Lime sul. 1-40 Lead 2-100**	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100
A-1-a	12 ft. rods Bordeaux nozzles	Lime sulfur 1-25	Lime sulfur 1-30	Lime sul. 1-40 Lead 2-100	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100
A-2	Guns	Lime sulfur 1-25	Lime sulfur 1-30	Lime sul. 1-40 Lead 2-100	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100
A-3 Check	Rods in calyx, guns in other	Lime sulfur 1-25	Lime sulfur 1-30	Lime sul. 1-40 Lead 2-100	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100	A. of lead 2-100
Date of application	Unsprayed			May 10, 1919	June 6, 1919*	June 23, 1919	Aug. 8, 1918	Sept. 2, 1919

*On account of codling-moth development 15-day spray delayed to 25 days; 30-day delayed accordingly; no scab.

**Powdered lead used in all applications.

variety are given in Table IX. The fruit at harvest time was separated as picked, from the ground to a height of 12 feet, and from 12 feet to the top of the trees. Apples which had been attacked by side and calyx worms were separated. The unsprayed Spitzenburg trees developed 53.6 percent worm injury. This was more severe than that which occurred in the Newtowns. No unsprayed check trees were kept for the Jonathan block. The results obtained in the Spitzenburg block are typical of the control obtained on the other varieties, and are presented in detail in Table IX. The slight differences obtained in the control with the guns and rods are probably due to experimental error. Both methods were found effective.

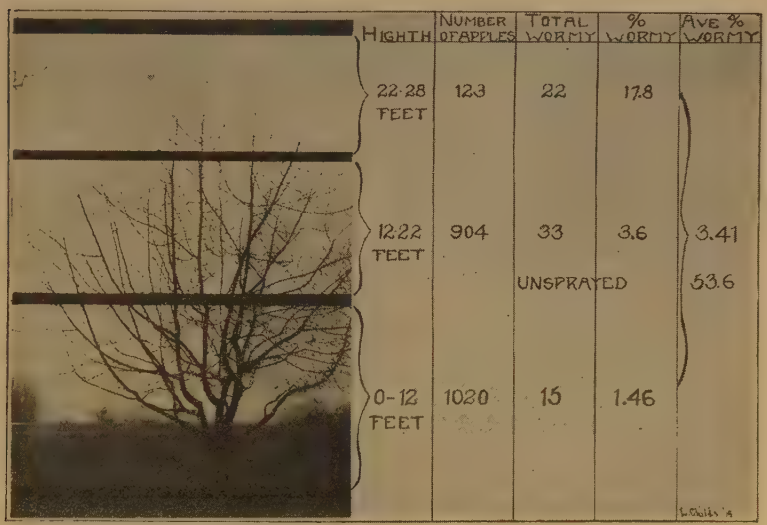

Fig. 8. Distribution of wormy apples on a tree in one of the experimental plots sprayed with guns on a 3½-h.p. sprayer. Good control was obtained up to a height of 22 feet. Above this point worminess rapidly increased. The average tree control was good, but poor in the tops. Unfortunately a tree was not analyzed where the 10-h.p. sprayer was used; the difference in top worminess was not observed to differ from fruits nearer the ground.

From the ground to 12 feet, an infestation of 1.46 percent occurred in the block sprayed with rods, and 1.08 percent in the gun block. In the area from 12 feet to the top of the trees 5.34 percent of the fruit became infested where sprayed with rods and 5.1 percent was so affected where the guns were used. The apples on some of these trees were very high (28 feet from the ground) and it seemed quite probable that little spray reached them. It was observed that very good control occurred up to a height of 22 feet, but above this point the number of wormy apples rapidly increased. See Fig. 8. In experiment A-2, Table IX, out of 123 apples taken above this height, 22 were wormy (18 percent). These are included in the record and materially raise the recorded percentage of injury. From a study of Table IX, it would appear that control was not exceptionally good above 12 feet. This percentage of injury is largely confined to apples above 22 feet, a condition which was found to be true in both rod and gun blocks. See Fig. 8.

TABLE IX. SUMMARY OF RESULTS CODLING-MOTH CONTROL, ORCHARD 4, 1919. SPRAY RODS VS. SPRAY GUNS

Experiment number	Height of fruit	Total apples	Total wormy		Av. worminess for Exp.	Total stings	Calyx worms		Side worms		Ratio of calyx to side worms in percent
				%				%		%	% to %
A-1 Rods	Ground to 12 feet	1020	15	1.46	3.41	53	1	.09	14	1.37	6.67 to 93.33
	12 feet to tree top	1027	55	5.34		58	5	.48	50	4.86	9.09 to 90.9
A-2	Ground to 12 feet	1006	11	1.08	3.19	27	1	.09	10	.99	9.09 to 90.9
Guns	12 feet to tree top	1003	53	5.1		47	10	.9	43	4.2	18.87 to 81.13
A-3 Rods in calyx,	Ground to 12 feet	1000	18	1.8	2.39	43	1	.1	17	1.7	5.5 to 94.4
guns in others	12 feet to tree top	754	24	3.16		56	5	.66	19	2.5	20.83 to 79.16
A-4* guns	Orchard run	1067	6	.56	.56	32	0	.0	6	.56	0.00 to 100.0
Check	Not segregated	1038	558	53.6	53.6	43	306	29.4	252	24.2	54.83 to 45.16

*Fruit checked at picking time 2 rows away from unsprayed check trees.

Experiment A-4 (Table IX) shows a condition of the fruit at harvest time, two rows away from the unsprayed check trees. These figures were obtained from apples noted at random at picking time. The unsprayed trees ran more than 50 percent wormy while less than 1 percent worminess was found on the sprayed trees. These results indicate clearly what can be done where worms are numerous by thorough, well-timed spraying in a single season. As the guns were used throughout the season in the orchard, the results also show that the gun can hold its own under such conditions. The summaries show that slightly better calyx-worm control was obtained with the rod than with the gun, where these instruments were used throughout the season. The percentage of calyx entrants is greater, however, than that which occurred in the gun block where rods were used in the calyx application only, though the degree of control is so nearly alike that there is little choice between the two methods. In the final summary (Table X), which includes all of the experiments and all varieties, the gun leads in control.

TABLE X. COMBINED SUMMARY OF RESULTS OF ALL VARIETIES SPRAYED. CODLING-MOTH CONTROL, ORCHARD 4, 1919.* SPRAY RODS VS. SPRAY GUNS

Experiment number	How applied	Total apples	Total worms	%	Total stings	%	Calyx worms	%	Side worms	%	Ratio of calyx to side worms in percent
A-1	Rods all sprays	4812	142	2.97	187	3.9	13	.26	129	2.68	9.15 to 90.84
A-2	Guns all sprays	5637	111	1.96	157	2.78	15	.26	96	1.7	13.51 to 86.48
A-3	Rods in calyx	1754	42	2.39	99	5.64	6	.34	36	2.05	14.28 to 85.71
Check	Not sprayed	1918	686	35.76	49	2.55	337	17.57	349	18.19	19.12 to 50.87

*Including Jonathan, Newtown, and Spitzenburg varieties.

Conclusions drawn from part or from the total summary indicate that either gun or spray rod will accomplish the desired results if properly used. A choice then depends upon the general workability of the two. The gun, therefore, because of the ease with which it can be handled, together with its speed and general economy, becomes the favorite with the orchardist.

LIMITATIONS IN THE USE OF THE SPRAY GUN

The spray gun cannot be used effectively on every spray outfit. As a matter of fact, our modern 3½- and 4-horse-power machines do not possess sufficient capacity and reserve to produce the ideal type of spray with two guns in operation. These machines will produce a fair spray, but it is a little too coarse and does not have the driving power back of it to do entirely effective work in the tops of large trees.

In practice, we find that the average output of a 3½-horse-power outfit, operating two guns, is about 4 gallons a minute for each. This is average running time including the shut-off in travelling from one tree to another. This means that, when both guns are in full operation, the output is considerably higher, approaching, if not equaling, the output of the pumps. Spray machines of this horse-power have a rated pump capacity of from 8 to 10 gallons a minute. When both guns are operating, an examination of the overflow pipe indicates there is little or no fluid passing over. The pressure as indicated on the gauge may be high (250 pounds perhaps) and still there is not the "life" that is observed in the spray that is thrown from a sprayer of 20-gallons-a-minute capacity with the pressure gauge reading approximately the same. A large overflow occurs on these machines when two guns are being operated, and it appears that it is this added reserve, rather than the pressure indicated, which determines the quality of the spray. One gun on a good 3½-horse-power outfit throws a spray very similar to that from the larger machine. In this case, we have about one-half of the pump output passing through the overflow pipe. Some of these observations which occur in practice are not entirely consistent from the standpoint of hydromechanics. It is hoped that investigational work now in hand may assist in clearing up some of these points.

It has also been noted that less spray is used per minute on the large outfits than with the smaller machines. This is probably due to the fact that the material is more finely broken up. A surface can be covered just as quickly with the fine particles, perhaps more quickly, than with a coarser spray. The result is that the gun is shut off more of the time and the average output per minute is reduced, the spray thus being saved.

FAILURES IN THE USE OF THE SPRAY GUN

Poor results that have been obtained with the spray gun are not due to the principles involved in applying the spray. Unsatisfactory control can be the result of the misuse of three, or perhaps rather the combination of three misused factors. These are poor equipment, poor work, and irregularity of application. Of the three factors, the first mentioned is probably the most important from the standpoint of the use of the gun. The other two factors are contingent upon the first. The spray gun is a useless accessory to a poor spray outfit; it is little better than nothing and will never give good results. Our up-to-date 3½-horse-power sprayers are indeed too small to handle two guns effectively. They will handle one in good shape. A machine of this power, in order to throw a spray of the proper quality, must maintain a pressure of at least 275 pounds. In the experimental work just referred to (orchard 4, Table IX) a machine of this character was used. In order to keep the spray in proper form, it was tuned up and pushed to the limit throughout the season. When you begin to force a gas engine and a pump, trouble begins, and the owner of this machine had his share. This condition of affairs existed in many orchards throughout the Valley and was typical of no particular make of sprayer. A spray machine, in order to last as long as it should and at the same time give results, must have a liberal reserve. A machine of 10 horse-power is none too powerful. Such spray machines are now coming into use, and it will be a question of only a very few years until all the present so-called modern sprayers will go into the discard on acreages of any great size. The results given for orchard 1, Table VII, were obtained with one of these large-type sprayers.

The gun, where operated with small inferior equipment, has given a very poor account of itself. The writer has carefully checked up the results obtained in several orchards where poor equipment has been used. The growers tried to do good work and timed their applications well. Breakdowns and low pressure, which is usual as a rule when a machine is not working right, have led to very poor results. The lower apples, as a rule, came through the season in very good shape. In 1918, in one of these orchards under observation, the following records were made. Apples growing below 12 feet developed a worm infestation of 3.55 percent. Apples growing between 12 feet and the top of the trees developed an infestation of 17.8 percent (Fig. 10.) There is only one explanation for this condition and that is the fact that the spray was not applied properly to the tops of the trees.

Fig. 9. Two types of spray thrown from a gun. For close-range work the broad fan-shaped spray should be employed. The tops may be covered by using the narrower form. Avoid drenching; this often occurs before the art of spraying is mastered.

BEHAVIOR OF THE PROPER SPRAY—ITS REQUIREMENTS

Low pressure from these small-capacity outfits does not produce a spray of the proper consistency to accomplish a satisfactory coating. The liquid leaves the guns in a coarse, spattering stream. There is no fineness of division of the particles and the only way that a tree can possibly be covered is to drench it, thereby wasting much material. As has been said before, it is believed that finely divided spray has much the same consistency as the dust particles which control calyx worms and operates in the same manner in the case of properly applied liquid solutions. If this spray is not broken up into a light drifting mist (as shown in Figs. 5, 6, 9, and 11) the principle of calyx-worm control is destroyed and poor results are bound to follow. There is no possible chance of obtaining much calyx protection in tops of trees with a gun throwing coarse, spattering spray. This might possibly be accomplished from a tower. Gravity is the factor which allows the poison to reach the calyx end of the uppermost apples. The spray material must be placed there in the proper condition and in sufficient amount to effect a coating as it falls. A coarse spray goes up in large droplets and comes down in much the same form, a large portion passing over the tree in the form of an arc. Unless a very excessive amount of spray material is thrown into the tops of the trees only a few of the calyx ends will receive much spray.

METHODS OF APPLYING SPRAY WITH A GUN

Since the introduction of the spray gun and the large-sized sprayers, methods practiced in the orchards in applying spray have undergone some changes. At the present time, the most effective and easiest way in which the spraying may be done has not been determined. In the case of the 3½- and 4-horse-power outfits, most of the growers are spraying from the ground. With the larger machines, some are working from the ground, and others from a platform placed at the back of the machines (Fig. 6). Still others operate two guns from the top of the tank. Where the spraying is done from the machine, the outfit is driven between each two rows of trees, one side of which is sprayed in passing; upon returning in the next row, the trees are finished. The important thing to bear in mind is the fact that the trees must be covered. How this is accomplished is optional with the grower.

The results of experimental work carried on in 1919 indicate that more attention must be paid to the tops of large trees, especially if apples are produced at a height greater than 22 feet. (See Fig. 8). As our orchards grow older, it will undoubtedly become necessary to do some of the spraying from the top of the machine in order to obtain a good covering. It has been the observation of the writer, however, that it is not good practice to grow apples at a height greater than 25 feet. The great amount of labor required in harvesting these apples, together with the fact that the average picker bruises a large percentage of them, makes them very expensive to grow. It will be economy to keep the trees cut back so that little fruit is produced at these heights.

Heavy winds make thorough application of spray difficult; this is true with rods as well as with guns—probably more true of the latter. Under such conditions it is becoming a practice with some of our growers, when it becomes absolutely necessary to spray, to spray one side only of each tree, spraying with the wind. In so doing, they trust that the wind may die down or change to such an extent by the time one side of all the trees is covered that, upon the return, with conditions more favorable, a much better coating would result than if the trees were completely finished at one time. This method has worked out nicely in many cases but it doubles the amount of ground to cover and to some extent increases the cost of spraying.

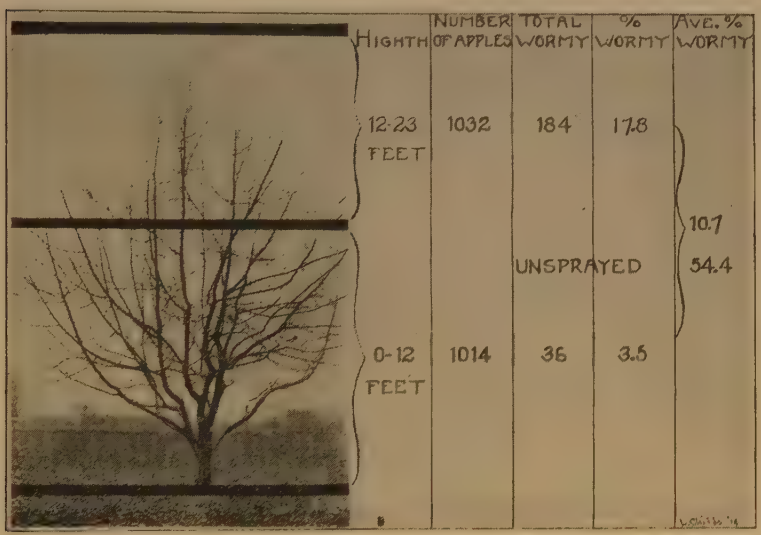

Fig. 10. Distribution of wormy apples on a tree sprayed with a gun on a poor spray outfit. Low pressure and a coarse, spattering spray was the rule. 17.8 percent of the fruit above 12 feet became wormy. Do not use a gun on a poor spray outfit—stay with the rods.

COMPARTIVE COSTS WITH DUST, SPRAY ROD, AND SPRAY GUN

It is an established fact that apples cannot be produced continuously in a given section without following a definite spraying schedule throughout each year. A few of the younger orchards and some of the more recent plantings in the Northwest are still more or less an exception to this rule. Their spraying requirements, however, will increase as their trees age, and it will be only a question of time until a definite yearly campaign will be necessary. Spraying charges, therefore, become a necessary, fixed expense in apple production which must be considered just as seriously as the paying of taxes on the property. To the average orchardist and the public in general these charges and the cost of the different applications are little known.

The season's charge is variable, one district with another, owing to the fact that the pests to be combated are not uniformly distributed throughout the apple-growing sections of the country. Indeed, we find that this charge cannot be uniform one season with another in our own district on account of various influences which affect our insect and disease enemies in different seasons. Our growers each year are given a spray calendar which outlines a schedule of applications suited to all requirements for best control under most unfavorable conditions. This schedule includes nine or ten applications of different sorts. As the season progresses, however, weather conditions largely determine the workability of the schedule. Our station issues recommendations based upon the actual conditions of insects or disease at the time different sprays should be applied. It thus works out that many of the applications can be omitted, those actually applied averaging from five to seven a season.

In 1917, the first definite cost figures for each application used at Hood River were obtained. The work was carried on in connection with the dust investigation which was under way at that time. In Table XII a summary is given showing the cost of codling-moth and scab control with different applications. This investigation included dusting, spraying with twelve-foot rods used on a 3½-horse-power engine; spraying with guns operated by a 3½-horse-power engine; spraying with guns operated by a 10-horse-power engine. Owing to the fact that the guns were not in use and the 10-horse-power engine was not available at the beginning of 1917 spraying season, the figures for these two methods of application were not obtained during that season, but were obtained in 1918. The operation charges, including cost of materials, as presented in the table, are those that existed in 1917, which enables the presentation of comparative costs resulting from use of the four methods. A six-acre unit is used as a basis for comparison. This was the actual size of plot 1, the dust plot. Plots 2 and 3 each contained twenty acres while plot 4 contained ten acres. The figures used, therefore, represent six-twentieths and six-tenths, respectively, of the total cost which occurred in orchards where the information was obtained. In the summary, the total costs are as they occurred in 1917 and are compared with figures showing the expense involved in 1920 to do the same work.

Some differences of opinion exist as to the amount that should be a fair charge for team and sprayers of a given horse-power. The figures given are considerably less than those charged by individuals to do outside spraying. They could not do the work for the consideration given. On the other hand, a fair charge could not be arrived at if the growers who own this spraying machinery charged the prevailing wage for the use of sprayer and team. In other words, the grower saves a good sum by owning his machine and the figure charged is believed to include cost of operation plus depreciation. In 1917, the 3½-horse-power machine and team were charged at 50 cents an hour; the 10-horse-power outfit was charged at 81 cents an hour, this difference being based upon the comparative cost of the two machines. In 1920, a charge of 60 cents and 97 cents, respectively, is made. Three gallons of gasoline a day are charged against the 3½-horse-power machine and six gallons a day against the 10-horse-power outfit. Oil is used in the same proportion at

the rate of about one-half pint and one pint a day. These figures are based upon average field usage. Labor was charged at 30 cents an hour in 1917 and at 40 cents an hour since that time.

TABLE XI. MATERIAL AND LABOR CHARGES USED IN COST TABLES DURING 1917, 1918, AND 1919

	1917	1918	1919	1920*
Lime sulfur per bbl.—50 gals.	$ 6.50	$ 9.00	$ 9.25	$ 9.25
Arsenate of lead—paste per hundred	8.00	13.75	11.50	14.00
Arsenate of lead—powder per hundred	.....	29.00	28.00	30.00
Dust sulfur per hundred 100%	3.60	5.00	5.00	5.00
40-50-10 (filler-sulfur-lead) per hundred	5.40	.....	6.25	6.25
Miscible oil, per gal.	.....	.36	.36	.36
Bluestone per hundred	.....	11.75	11.50	11.50
Lime per hundred	.....	2.50	3.25	3.25
Gasoline per gal.	.20	.25	.26	.29
Oil (Lub.) per gal.	.80	.80	1.00	1.00
3½ h.p. team and sprayer per hour	.50	.50	.60	.60
10 h.p. team and sprayer per hour	.81	.81	.97	.97
Labor per hour	.30	.30	.40	.40

*Approximate.

The number of sprays required in 1917 was greater than the average yearly requirement for scab and codling-moth control. Up to 1917, apple scab had been very prevalent throughout the district and it was advisable to take every precaution to prevent its spread. The thorough work undertaken throughout the Valley by nearly every orchardist, and the unfavorable weather conditions for scab development, have practically eliminated scab from the Hood River Valley. Since 1917, scab has been a minus quantity, developing only slightly on unsprayed check trees which have been surrounded by trees well sprayed. Table XII presents data for one application which ordinarily is not needed. The average age of the trees used in obtaining these figures was fourteen years.

The table shows that 2705 pounds of dust were used on the six acres in plot 1 during the season at a total cost of $144.28. Liquid was applied in plot 2 with the rods, using a 3½-horse-power machine at a cost of $146.95; 10,680 gallons were used. The year following, the same machine, with one gun, on plot 3, used 12,000 gallons of spray at a cost of $122.72 and the 10-horse-power sprayer with two guns, applied 11,988 gallons on plot 4 at a cost of $124.82. It will be noted that the old method of application with the rods was the most costly of the four systems and also that the single gun on the 3½-horse-power engine was the most economical. The actual cost is not, however, the most important factor involved; this is discussed later.

The most significant information is listed under the columns Man hours and Team hours in Table XII. The column, Team hours, shows actual running time as it occurred in the orchard and actual time involved in spraying. To the average orchardist the large amount of time required for spraying has been the greatest difficulty. The speed with

TABLE XII. SUMMARY OF COMPARATIVE COSTS—CODLING-MOTH AND SCAB GUNS ON 10 H.P. MACHINE. (FIGURES TAKEN

Application	Plot	Material and method used	Power used	Dust used	Gallons lime sulfur used			Pounds lead used (paste)		
Delayed dormant	1	Sulfur dust	3½ h.p. duster	665						
	2	Lime sulfur 1-25 applied with guns	3½ h.p. sprayer		82.8					
	3	Lime sulfur 1-25 applied with guns	3½ h.p. sprayer			76.8				
	4	Lime sulfur 1-25 applied with guns	10 h.p. sprayer				84			
Pink	1	Sulfur dust	3½ h.p. duster	650						
	2	Lime sulfur 1-35 applied with rods	3½ h.p. sprayer		41.3					
	3	Lime sulfur 1-35 applied with guns	3½ h.p. sprayer			54.6				
	4	Lime sulfur 1-35 applied with guns	10 h.p. sprayer				56			
Calyx	1	85-15 dust (Sulfur and lead)	3½ h.p. duster	420						
	2	Lime sulfur 1-35 Lead 4-100 applied with rods	3½ h.p. sprayer		39.3			55.2		
	3	Lime sulfur 1-35 Lead 4-100 applied with guns	3½ h.p. sprayer			59.7			84	
	4	Lime sulfur 1-35 Lead 4-100 applied with guns	10 h.p. sprayer				56			77
Fifteen day	1	85-15 dust (Sulfur and lead)	3½ h.p. duster	300						
	2	Lime sulfur 1-40 applied with rods	3½ h.p. sprayer		46.1					
	3	Lime sulfur 1-40 applied with guns	3½ h.p. sprayer			41.1				
	4	Lime sulfur 1-40 applied with guns	10 h.p. sprayer				48.6			
Thirty day	1	40-50-10 dust (filler, sulfur-lead)	3½ h.p. duster	320						
	2	Lime sulfur 1-50 Lead 4-100 applied with rods	3½ h.p. sprayer		33.4			76.8		
	3	Lime sulfur 1-50 Lead 4-100 applied with guns	3½ h.p. sprayer			43.2			86.4	
	4	Lime sulfur 1-50 Lead 4-100 applied with guns	10 h.p. sprayer				42			84
3rd Codling-moth	1	85-15 dust (filler and lead)	3½ h.p. duster	350						
	2	A. of lead 4-100 applied with rods	3½ h.p. sprayer					74.4		
	3	A. of lead 4-100 applied with guns	3½ h.p. sprayer						90	
	4	A. of lead 4-100 applied with guns	10 h.p. sprayer							77.4
Total costs, amounts, and materials used	1	Dust	3½ h.p. duster	2705						
	2	Rods	3½ h.p. sprayer		247.9			206.4		
	3	Guns	3½ h.p. sprayer			275.4			260.4	
	4	Guns	10 h.p. sprayer				286.6			238.4
Plots 1 and 2 1917 Record										
Plots 3 and 4 1918 Record										

CONTROL WITH DUST, SPRAY RODS, SPRAY GUNS ON 3½ H.P. MACHINE AND FROM 6 ACRE BLOCKS, TREES 14 YRS. OLD.)

Gallons dilute spray used			Total labor required: man-hrs.				team-hrs.				Total costs 1917 for six acre blocks: Dust	Rods	3½ h.p guns	10 h.p. guns	1920
			6.5				3.2								
2,070				28.2				14.1							
	1,920				14.5				12						
		2,106				15.5				7.75					
			6.5				3.3								
1,590				27				13.5							
	1,920				12.2				10.5						
		1,944				14.5				7					
			5.7				3								
1,380				23.4				11.7							
	2,100				15.5				12.5						
		1,944				14.5				7.25					
			5				2.5								
1860				30				15							
	1,650				14				11						
		1,944				14.5				7.25					
			5				2.5								
1,920				30				15							
	2,160				18				13.5						
		2,106				15.5				7.75					
			5				2.7								
1,860				30				15							
	2,250				17				9						
		1,944				14.5				7					
			33.7				17.2				$144.28				$190.66
10,680				168.6				84.3				$146.95			199.92
	12,000				91.2				68.5				$122.72		170.74
		11,988				89				44				$124.82	171.23
	Average cost per acre, 1917										$24.03	$24.49	$20.45	$20.80	
	Average cost per acre, 1920										$31.77	$33.32	$28.45	$28.54	

Fig. 11. The "life" and quality of spray thrown from a gun vary directly with the power back of it and the pump capcaity. The greater the pump reserve the better will be the quality of the spray. Here we have a very finely broken up spray thrown in nearly a direct line for a distance of 25 feet.

which dust can be applied has always been its greatest merit. The handicap encountered in the use of dust, as has already been discussed, has been sufficient to eliminate it from serious consideration under our conditions. It was found that the time required for making all six applications on six acres was but 17.2 hours. Here it was materials rather than labor cost which brought up the total charge to next to the top. It required 84.3 team hours and 168.8 man hours of tedious work to spray the plot successfully with the rods. Here the labor charge brought up the cost to such an extent that it led the list. The large amount of time required was given at a sacrifice of other orchard practices of nearly equal importance. The spray gun (one gun used and for the most part with no driver) required 68.5 team hours and 91.2 man

Fig. 12. The result of drenching the lower portions of the trees with lime-sulfur in the delayed dormant and pink applications. The edges of many of the leaves have been badly burned and the foliage appears thin. This burning of the tender foliage has not been accompanied with serious results; the tree quickly recovers. It is best to avoid this injury, however, as much as possible.

hours, a saving of 15.8 team hours and 77.4 man hours over the old method of application with the rods. With the 10-horse-power sprayer, 44 team hours and 89 man hours were required, 40.3 team hours and 79.6 man hours were saved as compared to applications made with rods. In comparing the 3½-horse-power sprayer with that of the 10-horse-power outfit, the man-hour saving did not prove very great, being only 2.2 hours. This was due to the fact that the driver did the spraying for the most part. In the case of team hours, there is a great difference—24.5

hours. This difference could be further reduced owing to the fact that three guns could be operated, where practicable, with a decided saving in team hours or actual running time.

The 1917 costs per acre for the four systems for scab and codling-moth control were found to be $24.03 for dust, $24.49 for spray rods, $20.45 for one gun on 3½-horse-power machine, and $20.80 for two guns on the 10-horse-power machine. At the present prices (1920) this per-acre cost would be as follows: dust $31.77, spray rods $33.32, gun on 3½-horse-power machine $28.45, two guns on 10-horse-power machine $28.54. The ease with which the spray may be applied from a large machine, the perfect quality of the spray produced, and the great saving of time resulting leads the writer to believe that the large machine is by far the more economical for the average orchardist.

THE ECONOMY OF SPRAYING PRACTICES IN PEST CONTROL

Since the time when the information which has just been discussed was obtained, further data relative to cost of orchard spraying have been gathered. During the past three years, questionnaires were sent out to a large number of growers. The list included orchardists who were obtaining maximum results from their spraying practices, those whose results were fair, and some others whose results were not satisfactory. Rather close watch of operations was kept in these orchards during

Fig. 13. Applying spray with rods. This method was found to be the most expensive and no more effective than sprays properly applied with a gun. It takes twice as long to cover the trees in this manner as with guns on a 10-horse-power machine and the work is much more laborious. If your sprayer is not first-class, however, continue using the rods.

TABLE XIII. COMPLETE COST RECORDS OF SPRAYING OPERATIONS IN TYPICAL 20 ACRE ORCHARD, HOOD RIVER, OREGON. TREES 13 YRS. OLD 1918; 14 YRS. OLD 1919*

Application and strength used	Spray used	Concentrate used	Lead used	Labor: Man hours	Labor: Team hours	Cost of material	Cost labor and machine	Total costs	Ave. cost acre	Ave. tree cost	Gals. per tree used	Ave. gal. per tree
20 Acres 13 yrs. old, 1358 trees.				1918								
	gals.	gals.	lbs.									
1 Oil 6-100	6,300	378		70	40	$136.08	$ 47.92	$184.00	$ 9.20	$ 0.135	4.6	
2 Delayed dormant	6,400	256		49	40	46.08	40.47	86.55	4.32	.063	4.7	
Lime sulfur 1-25												
3 Pink spray	6,400	213		41	34	38.34	34.17	72.51	3.62	.053	4.7	
Lime sulfur 1-30												
4 Calyx spray	7,000	199.5	315	52	42	35.91	42.64	122.06	6.10	.082	5.1	
Lime sulfur 1-35						43.52						
Arsenate of lead 4½-100												
5 30-day spray	7,200		324	46	36	44.55	37.08	81.63	4.08	.060	5.3	
Arsenate of lead 4½-100												
6 3d codling-moth	7,500		337.5	61	45	46.40	47.48	93.88	4.69	.069	5.5	
Arsenate of lead 4½-100												
7 Sept. codling-moth	5,500		247.5	56	28	34.70	35.92	70.62	3.53	.052	4.0	
Arsenate of lead 4½-100												
8 Fall Bordeaux	6,400		(768)	100	43	92.35	60.06	162.39	8.31	.119	4.7	
Bluestone 12-100			(768)			9.98						
Lime 12-100												
Season totals	52,700	668.5§	1,224†	475	308	$527.90	$345.74	$873.63	$ 43.65	$ 0.633	38.4	4.8
20 Acres 14 yrs. old, 1358 trees.				1919								
1 Oil 6-100	6,100	366		80	40	$133.59	$59.32	$192.91	$ 9.64	$ 0.142	4.5	
2 Pink spray	6,000	199.8		71	39	36.86	55.04	91.90	4.59	.067	4.4	
Lime sulfur 1-30												
3 Calyx spray	7,800	222.3	156	84	42	41.11	61.28	139.83	6.99	.102	5.7	
Lime sulfur 1-35						37.44						
Arsenate of lead 2-100												
4 15-day (delayed)	8,400		168	38	38	40.32	41.16	81.48	4.07	.06	6.1	
Arsenate of lead 2-100												
5 30-day (delayed)	7,000		140	39	39	33.60	42.26	75.86	3.79	.055	5.1	
Arsenate of lead 2-100												
6 3d Codling-moth	8,000		160	79	53	38.40	67.79	195.99	9.79	.144	5.8	
Arsenate of lead 2-100						89.80						
Bordeaux 4-6-50												
7 Fall Bordeaux	7,200			90	45	114.04	66.73	180.77	9.78	.133	5.3	
Bluestone 12-100												
Lime 12-100												
Season totals	50,500	422.1§	624**	481	296	$565.16	$393.58	$958.74	$ 47.95	$ 0.703	36.9	5.27

*For most part sprayed with one gun on 3½ h. p. machine.
§Lime sulfur.
**Powdered lead.
†Paste lead.

TABLE XIV. SPRAYING COSTS IN TWO EXCELLENT ORCHARDS IN FULL BEARING

In orchard 10 good results have been the rule; in 11 poor to fair. Why? The average usage per tree gives the answer.

10 acres. 636 trees. 17 yrs. old. Orchard 10*

	Application and strength used	Spray used	Concentrate used	Lead used	Labor		Cost of material	Cost labor and machine	Total cost	Ave. acre cost	Ave. tree cost	Amt. spray per tree	Ave. gals. per tree
					[illegible]	[illegible]							
		gals.	gals.	lbs									
1	Oil 6-100	5,400	324		40	20	$116.64	$ 21.52	$142.16	$ 14.21	$ 0.235	8.54	
2	Delayed dormant	3,510	140.4		26	12	25.27	20.52	45.77	4.57	.072	5.5	
	Lime sulfur 1-25												
3	Pink spray	3,240	91.2		24	12	16.58	18.91	35.44	3.54	.056	5.1	
	Lime sulfur 1-35												
4	Calyx spray	3,249	71.3	129.6	24	12	17.82	18.91	49.67	4.96	.078	5.1	
	Lime sulfur 1-45												
	Arsenate of lead 4-100												
5	30-day spray						12.54	18.91	36.72	3.67	.058	5.1	
	Arsenate of lead 4-100	3,240		129.6	24	12	17.82						
6	3d codling-moth	3,510		140.4	26	13	19.30	20.59	39.89	3.98	.062	5.5	
	Arsenate of lead 4-100												
7	Sept. codling-moth	3,420		128.6	24	12	17.82	18.91	36.72	3.67	958	5.4	
	Arsenate of lead 4-100												
8	Fall Bordeaux	5,400			30	20	76.14	28.52	112.08	11.20	.179	8.5	
	Bluestone 12-100						8.42						
	Lime 12-100												
	Season totals	30,569	403.644	529.2**	214	114	$328.76	$176.62	$505.38	$ 50.53	$ 0.799	48.7	6.04
	11 acres. 701 trees. 8 yrs. old.				Orchard 11§								
1	Oil 6.5-100	2,475	241.9		30	15.	79.56	17.73	97.29	8.84	.138	4.8	
2	Pink spray	2,600	74.1		31	15.5	18.33	18.82	31.65	2.81	.045	3.7	
	Lime sulfur 1-35												
3	Calyx spray	3,600	102.6	100.8	24	12	18.46	14.19	61.88	5.62	.088	5.1	
	Lime sulfur 1-25												
	Arsenate of lead 2.8-100						29.23						
4	15-day spray	3,100		62	24	24	17.88	21.19	39.07	3.55	.055	4.4	
	Arsenate of lead 2-100												
5	30-day spray	2,750		55	20	20	15.95	17.66	33.61	3.05	.048	3.8	
	Arsenate of lead 2-100												
6	3d codling-moth	2,750		55	20	20	15.95	17.66	33.61	3.05	.048	3.8	
	Arsenate of lead 2-100												
7	Fall Bordeaux	3,600			40	40	50.76	35.32	91.69	8.33	.13	5.1	
	Bluestone 12-100						5.61						
	Lime 12-100												
	Season totals	21,800	176.7††	272.8	189	146.5	$246.73	$142.07	$388.80	$ 35.25	$ 0.552	30.7	4.39

*1918 figures. †Probably slightly excessive.

§1919 figures. This accounts for the difference in number of sprays used. **Paste lead. ††Lime sulfur.

the years involved. The figures obtained bring out some interesting facts. As an invariable rule, it was found that the orchardists who used the least amount of spray were the ones who suffered the greatest loss from insect and disease enemies.

Tables XIII and XIV show the results of this investigation. Table XIII shows the comparative cost record for spraying a twenty-acre orchard in 1918 and 1919. This orchard was typical in every respect. The trees are uniform and are representative in size according to their age. In 1918, the trees were thirteen years of age and in 1919, fourteen years. The varieties are Newtown and Spitzenburg, equally divided. The orchardist is thorough in every detail and his results have been as nearly perfect as can be accomplished with spray. The work was done for the most part with one gun used on 3½-horse-power sprayer of well-known make.

Fig. 14. Coating of spray existing on average apples taken at a height of eight feet which had been sprayed with rods. This appears to be a better distributed covering than shown in Fig. 19 (sprayed with guns) on apples taken at the same height. The finer particles do not show in the picture.

Two guns were found to produce a rather inferior spray, while with one gun it was very good. A driver was used a portion of the time owing to the fact that the team was young and inexperienced with spraying. This fact increased the labor cost somewhat. In all details, complete economy was practiced as far as possible. In 1918, 52,700 gallons of spray were used on 1328 trees in 8 applications, or an average of 4.8 gallons of spray to the tree for each application. The sprayer ran 30.8 days (ten hours each) during the season and it required 47.5 days of labor. In 1919, with the trees one year older, 50,500 gallons were used in 7 applications, or an average of 5.2 gallons a tree for each application. The sprayer, during this season, was in operation 29.6 days requiring 48.1 days of labor. In other words, the spray machine ran about one-sixth of the time during the growing or producing season in a twenty-

acre orchard. We find that the 10-horse-power sprayer, Table XIV, orchard 10, sprayed a 17-year-old orchard of 10 acres in 11.4 days, which would be the equivalent of 22.8 days for twenty acres, during which time, using the same proportions, it would have used 61,920 gallons of spray as compared to 50,500 gallons for the small machine. Every day gained in the orchard during the growing season is an important one in production and the speed in which a covering can be given is equally important in accomplishing satisfactory control. These points again show the benefit that may be derived from using a sprayer with an abundant amount of power.

Growers should study these cost tables carefully. All of the points presented will be interesting and instructive. The uniform average obtained in each application throughout the season has an important meaning. (Note next to last column in Table XIII). In the reports received from growers who failed to accomplish satisfactory control, the average usage was far from uniform. One spray would average about 8 gallons to the tree and the next application about 2.5 gallons. A condition of this sort means that there is something decidedly wrong in the spraying practice employed.

TABLE XV. AVERAGE SPRAY REQUIREMENTS FOR BEST CONTROL ON TREES OF DIFFERENT AGES*

Age of trees	Miscible oil gallons per tree	Summer applications for scab and codling-moth	Fall Bordeaux
11	4.1	4.1	
12	4.5	4.5	5.0
13	5.6	4.5	5.1
14	7.0	5.2	
15	7.2	5.6	6.1
17	8.0	6.0	7.4

*Based upon information obtained in a number of successfully sprayed orchards during the years 1917, 1918, and 1919.

The total cost of spraying the orchard presented in Table XIII was $873.63 in 1918 and $958.47 in 1919. The average acre cost was $43.65 and $47.95, respectively. The per-tree cost was 63 cents and 70 cents, or an average of 8 cents a tree for each application in 1918 and 10 cents a tree in 1919. Costs based upon yields during these two years in this orchard averaged about 9 cents a box as a spraying charge.

The data presented in Table XIV are given to show the difference in cost between good and only-fair spraying. The orchards in question are excellent ones; the trees are large and uniform. Orchard 10 consists of 10 acres of approximately 630 acres, 17 years of age. Orchard 11 consists of 11 acres, or approximately 700 trees, 18 years of age. These trees will average slightly larger than those found in orchard 10. By referring to the table, it will be found that the greater amount of spray (30,960 gallons) was used on the 10 acres of 17-year-old trees and 21,800 gallons were used on the 11-acre orchard. One more application was used on orchard 10, a condition which approximates the difference that was used owing to the extra acre in orchard 11. The owner of orchard 11 has reported severe losses from leaf-roller and codling-moth for several years. In 1918, but 17,550 gallons of spray were used during the season in this orchard. In orchard 10 the results have been much better and in

1919 were nearly as good as spraying can produce. Orchard 10 was sprayed with a 10-horse-power sprayer, while orchard 11 was sprayed with a 3½-horse-power sprayer, using 2 guns. In looking over the "average gallons spray per tree" column, Table XIV, it will be observed that there is a consistent usage of spray in orchard 10 during the season. The oil and bordeaux sprays have been heavy, probably somewhat in excess. It was found in the large number of reports received from growers that the amounts of spray used in these two applications averaged considerably more than the summer applications. For average spray requirements of trees at different ages see Table XV. In orchard 11, irregularity of average usage has occurred throughout the season, a factor which has been observed to be closely related to poor results in control. The average usage per tree in orchard 11 was found to be 4.39 gallons as compared to 6.08 gallons in orchard 10, or a difference of 1¾ gallons in each application. The average cost a gallon of this diluted spray is .0178 cents in orchard 11. At an average cost of 3 cents per application or 21 cents per tree during the season, excellent as compared to poor pest control would have been obtained.

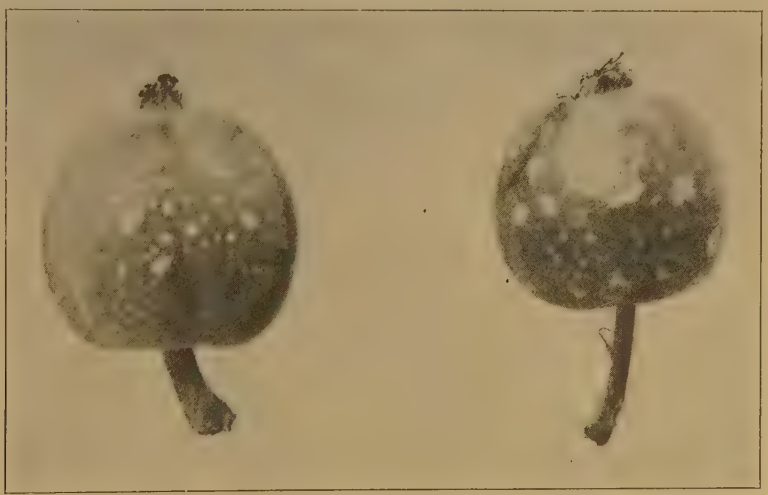

Fig. 15. Coating of spray existing on average apples taken at a height of eight feet which had been sprayed with guns. These apples have the appearance of being oversprayed, much of the material having run together in large droplets. This condition should be avoided as much as possible. The finer particles do not show in the picture.

The importance of this initial spraying investment can be shown still further. In orchard 10, the culls resulting from leaf-roller and codling-moth injuries amounted to 5 percent of the total production or approximately 200 boxes of apples. In orchard 11, this loss amounted to approximately 18 percent or a loss of about 800 boxes. The difference then between the results from satisfactory spraying and those from unsatisfactory spraying is 600 boxes or six-sevenths of a box per tree. This fruit, if of good quality, is worth at least $1.25 per tree. The net profit on an increased spraying charge of 21 cents per tree would have

been $1.04. **This is 495 percent on the investment.** There is not another practice in orcharding that will net this return.

The amount of spray required to accomplish a satisfactory coating of the tree is a question that is often asked. This naturally depends upon the age of the tree and its size at a given age. The size to which it has grown depends largely upon soil conditions and methods of handling during the years of its growth. For this reason, there would be

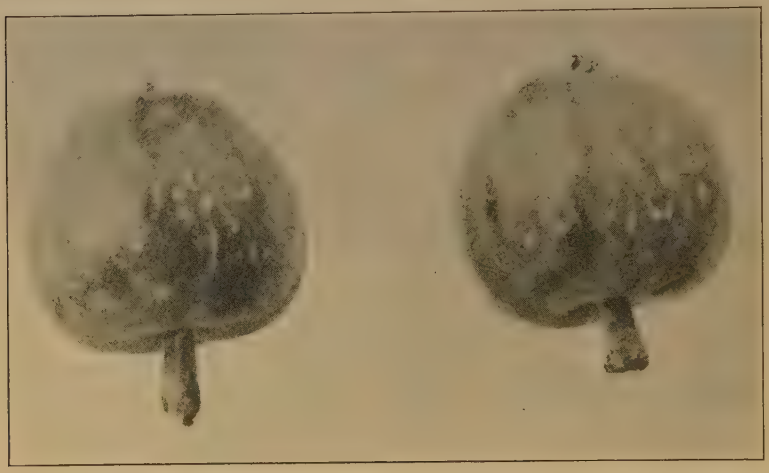

Fig. 16. Coating of spray existing on average apples taken at a height of 20 feet which were sprayed with rods. Covering is inclined to be spotted and is not made up of as fine particles as shown in Fig. 21.

Fig. 17. Coating of spray existing on average apples taken at a height of 20 feet which had been sprayed with a gun. Very few coarse blotches are present and for the most part the covering is evenly made up of very fine particles of spray.

quite a variation in different localities in the growth attained by trees of the same age. The figures on amounts of spray required have been taken in orchards in which the growth has been quite uniform and the trees have probably reached a maximum size during the period of growth considered. The summary from a relatively large amount of data, gathered from uniformly representative orchards, gives averages per tree of different ages, which are shown in Table XV. The figures show that some applications require more spray than others; the oil applications requiring the most material for an effective coating; the fall bordeaux application second; and the summer sprays, which have been averaged together, third. One would imagine that the calyx application would demand more spray for a satisfactory covering than the others but the averages that have been obtained do not indicate that this is the case.

Probably the greatest contributing factor in poor pest control is the use of an insufficient amount of spray material. In analyzing reports from a large number of growers, it has been found invariably that those who complain of unsuccessful pest control are those who use relatively small amounts of material. There is absolutely no economy in trying to reduce the amount of spray used. A single neglectful practice often results in a loss which would pay twice over the cost of spraying. The successful grower will be the one who makes every practice pay.

SUMMARY

1. The dusting method, if properly applied, has been found to control effectively scab and codling-moth in the Hood River Valley.

2. Continual wind, which often occurs during the spring, makes it impossible to do effective dusting much of the time. Dust applied under these conditions has been a failure. Present-known dust materials will not effectively control anthracnose, mildew, leaf-roller, and the various apple-aphids. These numerous limitations in general usage make dusting under Western conditions inadvisable.

3. Dust controls calyx worms. The material is not "driven" into the calyx cups. Action of gravity is largely responsible. This principle is applicable in the case of materials properly thrown from a spray gun. The fine particles behave in the same manner as they do with dust, and calyx worms are controlled with liquids so applied.

4. Comparative tests carried on with spray rods and guns in codling-moth control produce results practically identical. Effective control was obtained with each.

5. The spray gun cannot be used on every spray outfit. Sprayers of 3½- and 4-horse-power do not possess sufficient reserve power to operate two guns in an entirely satisfactory manner. They will operate one gun effectively. Guns will not give good control on machines smaller than this.

6. Small-capacity machines (3½-horse-power) throw coarse, spattering sprays from two guns unless tuned up and forced. In this event, engine trouble continually occurs. The spray must be finely broken up and supplied with sufficient force back of it to place the materials in the tops of the trees.

7. There is all the difference in the world in the "life" of the spray thrown from a 3½-horse-power sprayer and that of one from a 10-horse-power sprayer with the pressure gauges reading approximately the same. There is no overflow in the case of the smaller machine and a liberal one in the case of the larger.

8. On a 3½-horse-power sprayer use only one gun if you desire the right kind of spray. Keep a pressure of at least 250 pounds.

9. The cost of applying dust, spray with rods, spray with guns using a 3½-horse-power machine, and with guns using a 10-horse-power machine has been determined. Applications made with the rod are the most expensive. Sprays applied with one gun, using a 3½-horse-power machine, are the least expensive—a few cents less per tree than with the 10-horse-power machine. The great saving of time, however, resulting from the use of the big machine, together with the fact that a perfect spray is produced with no hardship to the machine, makes a big sprayer much more economical and efficient.

10. The cost of effective spraying in Hood River orchards of 13 and 14 years of age was found to be about $45.00 an acre, 63 to 70 cents a tree for the season. The cost is shown to be greater on older trees.

11. Orchardists whose reports show irregular average tree usage in the different applications, invariably report poor pest control. Those that show a uniform usage throughout the season have obtained good results.

12. A table is presented showing the average usage of spray per tree per application by growers who have obtained maximum pest control. Amounts used on trees 11 to 17 years of age are shown. The oil and fall bordeaux applications require more gallons to the tree than do the summer applications.

13. A summary of reports received from a large number of orchardists indicates that many could spend a little more per tree as a spraying charge and reap a decided benefit. An investment of 21 cents a tree more than already put into the spraying charge would have netted an orchardist $1.04 a tree, much more than enough to pay for the entire season's spraying cost.